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# EVALUATION OF STANDARD TIME WITH THE APPLICATION OF RANK POSITIONAL WEIGHTED METHOD IN THE PRODUCTION LINE

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***ABSTRACT***

***Assembly line balancing is one of the major concern as far as a manufacturing plant is considered. The plant productivity solely depends on this parameter and hence balancing and figuring out the idle time in a production flow becomes very mandatory. A production line of a high deck body is considered for this research work and time study is performed in order to determine the standard time for each process. Then, rank positional weighted method (RPW) is evaluated with the help of standardized data to solve the assembly line problem and defines the line efficiency which provides a better productivity in the existing flow line by reducing the idle time.***

***KEYWORDS: Cycle Time, Standard Time, Assembly Line, Rank Positional Weighted & Line Efficiency***

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**Original Article**

## INTRODUCTION

A set of work element having tasks which have a defined cycle time or operating time with a set of interrelated activities in a certain order. It is often desired to obtain a smooth flow of work in an industry and to achieve this, balancing of assembly line is a must. This plays a vital role in the production line. The observation of individual workstation is necessary as it depicts the time spent on that workstation and the area where it lacks in terms of idle time and mishandling. Also, the precedence diagram is drawn so as to a visual understanding of how the process flows and the interrelation between the activities. Hence, assembly line balancing is needed to achieve a targeted production rate within the stipulated time allotted as per the demands.

## LITERATURE REVIEW

Grzechca [1] described about the different assembly line structure in a manufacturing unit. The structure also largely depends on the modularity of the product. The measures of balance quality are defined which are indirectly related to cycle time. thus, the heuristics procedure helps in determining the variation in the cycle time according to the market demand. Kayar and Akylacin[3] applied different balancing methods with the help of operation time. Remaining time is calculated at each workstation and then analyzed using rank positional weight method (RPW). Jaggi et al., [4] minimized the idle time in the production line by determining the required workstation cycle time and theoretical number of workstations and accordingly computing line efficiency. Morshed and Palash [5] improved the productivity of the apparel industry by reducing the non-value added activities, cycle time and work load distribution which ultimately increases line efficiency. The problem of bottleneck was equalized using a proposed layout. Yadav and Singh [6] approached the standard method of Rank Positional Weight Method for solving problems of Assembly Line Balancing Problem. This method minimizes the workstations thereby minimizing the balance delay and improving the line efficiency. The main aim of doing this method to cut the slack time and get the task in the shorter

time. Prakash and Aneesh[7] focused on the improvement of an assembly line by reducing idle time and then applying rank positional weight method. The comparison is drawn from the existing time and the standard time proposed figuring out the non-value added time. Manoria et al., [8] evaluated multi product assembly line balancing problem using RPW technique. The flow chart provides a clear scenario of the program and an expert system is established. Chavare and Mulla[9] reduced the bottlenecks of an engine assembly by RPW method and increased the production by25%. Fonseca [10] applied fuzzy logic to the assembly line balancing and also validated it with RPW method to determine the idle time. Sharma et al., [11] evaluated assembly line problems to reach to ideal situation by various methods including RPW and Rank and assigned heuristics Maximum Backward Recursive Positional Weight. The assembly line parameters were tabulated and comparisons were drawn to determine the best method. Patel et al., [12] worked on the optimization of the sub-assembly and assembly line. The results from RPW method revealed that the idle time and balance delay is reduced drastically whereas the line efficiency was increased. These results will ultimately make the production line flow as there exists uniform workload distribution. Ghutukade and Sawant [13] used the RPW method for simple assembly line balancing increasing the production rate by 38%. Prasad et al., [14] optimized the assembly line for a batch production by RPW method. Also, the percentage of idle time and minimum number of workstation was determined to decrease the improper working schedule and lagging of material handling equipment. Ismail et al., [15] improved the assembly line of a bus manufacturer by doing calculation on standard time and subsequently preventing the imbalance assembly line in the production unit.

## RESEARCH METHODOLOGY

The methodologies used in this research work consists of Time study and assembly line balancing technique of rank positional weighted method.

- **Work Measurement/Time Study**

It is an important approach or study to measure the amount of work done on each workstation of an assembly line system i.e. the total completion time is recorded to specify the standards in the system. The analyst records the information related to the job completion. It is used to determine the normal and the standard time in order to complete the task. It also records the available information related to the system that ultimately determines the time standards of the assembly line system and thereby reducing the idle and waste activities in the system.

The parameters of time study are as follows:

- Normal time = observed time × rating factor
- Standard time = Normal time + Allowances
- Rating Factor = the performance of each worker in performing the job is rated.

Hence the overall rating of the worker is determined using the principles of Westinghouse rating factor. The rating factor is sub divided into four important categories (i.e.) Skills, Effort, Condition, Consistency.

The analyst is required to observe each category on each worker to determine the standard rating.

- **Rank Positional Weighted Method**

Rank positional weighted (RPW) is one of the assembly line balancing technique that determines the idle time and improves the line efficiency. According to Deshpande [2], it is a combination of largest candidate rule and kilbridge and western method.

In this method, the elements are arranged in a decreasing order of their positional weight. The positional weight of an element corresponds to the time of the longest path from the beginning of the element to the reminder of the network. A location is done similarly to the largest candidate rule, the only difference in the final element table should be arranged corresponding to the positional weight.

The parameters of assembly line balancing are as follows:

- Cycle time = (Total available production time)/ Total No. of units to be produced
- Min no. of workstations required (theoretical) = Total Work Content/Cycle time
- Balance delay = [(No of workstations*Cycle Time – Total Work Content)/ (No of workstations*Cycle Time)] x 100
- Line Efficiency = (100 – Balance Delay) %
- Line Smoothness Index

$$SI = \sqrt{\sum_{j=1}^{k}\left(S_{\max} - S_j\right)^2}$$

Where $S_{max}$ is the maximum station time and

$S_j$ is the station time

## CASE STUDY

The Autoline industry manufactures sheet metal components, sub-welding assemblies and assemblies, Foot Control Modules, parking brakes, hinges, cab stay and cab tilt, exhaust systems, tubular structures, fabrications, etc. for large OEMs in the Automobile Industry. The present research work focusses on the assembly line balancing of the high deck body. Data recorded in observing the ace high deck body assembly line.

- Total maximum production time = 12 hours/day = 720 min
- Breaks and maintenance/cleaning time = 60 + 40 min = 100 min
- Production time = 620 min.
- Average no. of workers = 70-72/day.
- Targeted body = 50/day.
- Idle time= 40 min /day

The assembly line consists of five stages that consists of floor line, main line, finishing line, front panel and side panel.

## Analysis of Standard Time

The observations in all the stages of production line are calculated using stop watch with five trails for the same process. The standard time is calculated for each workstation with rating factor and allowances allocated to the worker based on the performance for the specific line.

**Table 1: Floor Line Standard Time**

| Element Description | Observed Time (Stop Watch Reading) | | | | | Average Observed Time | Rating Factor(RF) | Normal Time | Allowances % | Standard Time (ST) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | | | |
| Fl-1 | 3 | 2.15 | 2.25 | 2.40 | 2.50 | 2.46 | 0.91 | 2.21 | 10% | 2.31 |
| FL-2 | 2.46 | 2.55 | 2.33 | 3.10 | 2.50 | 2.58 | 0.69 | 2.28 | 10% | 2.38 |
| FL-3 | 3 | 3.14 | 3.30 | 3.15 | 3.20 | 3.15 | 1.0 | 3.15 | 10% | 3.25 |
| FL-4 | 2.25 | 2.20 | 2.13 | 3 | 2.30 | 2.37 | 0.70 | 2.05 | 10% | 2.15 |
| FL-5 | 4.25 | 3.40 | 2.40 | 2.45 | 3.50 | 3.20 | 1.0 | 3.20 | 10% | 3.3 |
| FL-6 | 2.20 | 2.10 | 2.35 | 1.40 | 2.10 | 2.03 | 0.70 | 1.42 | 10% | 1.52 |
| **Total** | | | | | | **16.19** | | **14.31** | | **15.31** |

**Table 2: Main Line Standard Time**

| Element Description | Observed time (stop watch reading) | | | | | Average Observed Time | Rating Factor(RF) | Normal Time | Allowances % | Standard Time (ST) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | | | |
| ML-1 | 2.47 | 2.15 | 2.50 | 2.45 | 2.40 | 2.39 | 0.66 | 1.57 | 10% | 2.07 |
| ML-2 | 4 | 3.55 | 3.50 | 4.10 | 3.50 | 4.13 | 0.98 | 4.04 | 10% | 4.14 |
| ML-3 | 3.27 | 3.00 | 3.40 | 3.10 | 3.15 | 3.18 | 0.66 | 2.09 | 10% | 2.19 |
| ML-4 | 3.54 | 4.21 | 3.30 | 3.40 | 3.55 | 4 | 0.75 | 2.3 | 10% | 2.4 |
| ML-5 | 4.00 | 3.50 | 3.10 | 3.35 | 3.40 | 3.47 | 0.75 | 3 | 10% | 3.1 |
| ML-6 | 3.00 | 3.04 | 2.50 | 3.00 | 3.10 | 3.32 | 0.68 | 2.25 | 10% | 2.35 |
| ML-7 | 3.10 | 2.40 | 3.10 | 2.40 | 2.50 | 3.1 | 0.67 | 2.07 | 10% | 2.17 |
| ML-8 | 2.40 | 2.30 | 2.45 | 2.20 | 2.50 | 2.37 | 0.72 | 2.10 | 10% | 2.2 |
| ML-9 | 2.20 | 2.40 | 2.30 | 2.35 | 2.42 | 2.33 | 0.65 | 1.51 | 10% | 2.01 |
| **Total** | | | | | | **28.29** | | **21.33** | | **23.03** |

**Table 3: Finishing Line Standard Time**

| Element Description | Observed time (Stop Watch Reading) | | | | | Average Observed Time | Rating Factor(RF) | Normal Time | Allowances % | Standard Time (ST) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | | | |
| HD-1 | 2.30 | 2.40 | 2.35 | 2.40 | 2.50 | 2.39 | 0.69 | 2.04 | 10% | 2.14 |
| HD-2 | 2.20 | 2.35 | 2.40 | 2.25 | 2.30 | 2.30 | 0.70 | 2.01 | 10% | 2.11 |
| HD-3 | 2.40 | 2.37 | 2.30 | 2.39 | 2.45 | 2.38 | 0.38 | 1.30 | 10% | 1.4 |
| HD-4 | 2.10 | 2.05 | 2.18 | 2.10 | 2.09 | 2.10 | 0.71 | 1.49 | 10% | 1.59 |
| HD-5 | 3.10 | 3.30 | 3.15 | 3.40 | 3.25 | 3.24 | 0.65 | 2.10 | 10% | 2.2 |
| HD-6 | 2.46 | 3.00 | 2.45 | 2.40 | 2.35 | 2.53 | 0.38 | 1.36 | 10% | 1.46 |
| HD-7 | 9.20 | 8.55 | 10 | 10.10 | 9.50 | 9.47 | 1 | 9.47 | 10% | 9.57 |
| **Total** | | | | | | **24.41** | | **20.27** | | **20.47** |

**Table 4: Front Panel Geo Fixture Standard Time**

| Element Description | Observed time (stop watch reading) | | | | | Average Observed Time | Rating Factor(RF) | Normal Time | Allowances % | Standard Time (ST) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | | | |
| FP | 1.30 | 1.35 | 1.50 | 1.40 | 1.30 | 1.37 | 0.70 | 1.35 | 10% | 1.45 |
| FPG | 3 | 3.10 | 3.15 | 3.10 | 3.05 | 3.08 | 0.75 | 2.31 | 10% | 2.41 |
| S.P.M-1 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 1.0 | 2.50 | 10% | 3 |
| S.P.M-2 | 1.10 | 1.10 | 1.15 | 1.12 | 1.10 | 1.11 | 1.0 | 1.11 | 10% | 1.21 |
| IF-1 | 0.10 | 0.12 | 0.15 | 0.10 | 0.10 | 0.11 | 0.38 | 0.04 | 10% | 0.14 |
| **Total** | | | | | | **8.17** | | **7.31** | | **8.21** |

**Table 5: Side Panel Fixture Standard Time**

| Element Description | Observed Time (Stop Watch Reading) | | | | | Average Observed Time | Rating Factor(RF) | Normal Time | Allowances % | Standard Time (ST) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | | | |
| SPLH | 2.50 | 2.45 | 2.55 | 2.55 | 2.50 | 2.51 | 0.76 | 2.30 | 10% | 2.4 |
| SPRH | 1.50 | 2.05 | 2.00 | 2.10 | 1.55 | 2.24 | 0.75 | 2.08 | 10% | 2.18 |
| SPM-1 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.0 | 1.15 | 10% | 1.25 |
| SPM-2 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.0 | 1.10 | 10% | 1.2 |
| SPF | 2.30 | 2.45 | 2.40 | 2.30 | 2.35 | 2.36 | 0.76 | 2.19 | 10% | 2.29 |
| IF-2 | 2.55 | 2.50 | 3.05 | 3.10 | 3.10 | 3.26 | 0.74 | 2.41 | 10% | 2.51 |
| **Total** | | | | | | **13.02** | | **11.23** | | **12.23** |

Observed Total task time = 16.19 + 28.29 + 24.41 + 8.17 + 13.02 = 90.08 min

Total task time after standardization = 15.31 + 23.03 + 20.47 + 8.21 + 12.23 = 79.25 min

## Rank Positional Weighted Method

The rank positional weighted method requires cycle time in order to carry out the sequence of operations. Also, determining the minimum no. of workstation is mandatory to compute the total work content.

- Cycle time =Available time

  Reqd orders per day

  = 540 / 70

  = 12.4 min

- Minimum no. of workstations =Total Task Time

  Cycle Time

  = 79.25/ 12.4

  = 7

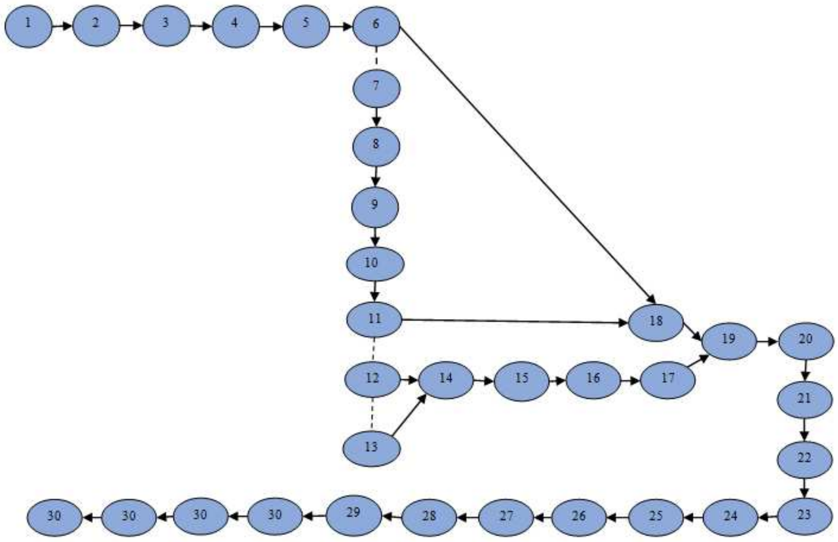


**Figure 1: Precedence Diagram**

Table 6 represents the production line configuration consists of the components in the process flow. The precedence diagram depicts the arrangement of the various components in the assembly line of manufacturing high deck body. The positional weights are calculated in accordance with the precedence diagram

**Table 6: Production Line Configuration**

| Components | Elements | Cycle Time (Min) | Precedence | Positional Weight |
|---|---|---|---|---|
| **Floor line-1** | 1 | 2.31 | --- | 58.01 |
| **Floor line-2** | 2 | 2.38 | 1 | 55.7 |
| **Floor line-3** | 3 | 3.25 | 2 | 53.32 |
| **Floor line-4** | 4 | 2.15 | 3 | 50.07 |
| **Floor line-5** | 5 | 3.3 | 4 | 47.92 |
| **Floor line-6** | 6 | 1.52 | 5 | 44.62 |
| **Front Panel** | 7 | 1.45 | --- | 51.31 |
| **Front panel geo** | 8 | 2.41 | 7 | 49.86 |
| **Spot permanent maching-1** | 9 | 3 | 8 | 47.45 |
| **Spot permanent maching-2** | 10 | 1.21 | 9 | 44.45 |
| **Inversion fixture-1** | 11 | 0.14 | 10 | 43.24 |
| **Side Panel LH** | 12 | 2.4 | --- | 50.68 |
| **Side Panel RH** | 13 | 2.18 | --- | 50.46 |
| **Spot permanent maching-1** | 14 | 1.25 | 12,13 | 48.28 |
| **Spot permanent maching-2** | 15 | 1.2 | 14 | 47.03 |
| **Spot permanent fixture** | 16 | 2.29 | 15 | 45.83 |
| **Inversion fixture-2** | 17 | 2.51 | 16 | 43.54 |
| **Main line-1** | 18 | 2.07 | 6,11 | 43.1 |
| **Main line-2** | 19 | 4.14 | 17,18 | 41.03 |
| **Main line-3** | 20 | 2.19 | 19 | 36.89 |
| **Main line-4** | 21 | 2.4 | 20 | 34.7 |
| **Main line-5** | 22 | 3.1 | 21 | 32.3 |
| **Main line-6** | 23 | 2.35 | 22 | 29.2 |
| **Main line-7** | 24 | 2.17 | 23 | 26.85 |
| **Main line-8** | 25 | 2.2 | 24 | 24.68 |
| **Main line-9** | 26 | 2.01 | 25 | 22.48 |
| **High deck-1** | 27 | 2.14 | 26 | 20.47 |
| **High deck-2** | 28 | 2.11 | 27 | 18.33 |
| **High deck-3** | 29 | 1.4 | 28 | 16.22 |
| **High deck-4** | 30 | 1.59 | 29 | 14.82 |
| **High deck-5** | 31 | 2.2 | 30 | 13.23 |
| **High deck-6** | 32 | 1.46 | 31 | 11.03 |
| **High deck-7** | 33 | 9.57 | 32 | 9.57 |

**Table 7: Line Balancing Results**

| Workstation | Element | Positional weight | Cycle time | Total work content | Ideal Time |
|---|---|---|---|---|---|
| **I** | 1<br>2<br>3<br>7<br>12 | 58.01<br>55.7<br>53.32<br>51.31<br>50.68 | 2.31<br>2.38<br>3.25<br>1.45<br>2.4 | 12.19 | 0.21 |
| **II** | 13<br>4<br>8<br>14<br>5 | 50.46<br>50.07<br>49.86<br>48.28<br>47.92 | 2.18<br>2.15<br>2.41<br>1.25<br>3.3 | 11.29 | 1.11 |
| **III** | 9<br>15 | 47.45<br>47.03 | 3<br>1.2 | 12.27 | 0.13 |

| | | | | | |
|---|---|---|---|---|---|
| | 16<br>6<br>10<br>17<br>11 | 45.83<br>44.62<br>44.45<br>43.54<br>45.24 | 2.29<br>1.52<br>1.21<br>2.51<br>0.14 | | |
| **IV** | 18<br>19<br>20<br>21 | 43.1<br>41.03<br>36.89<br>34.7 | 2.07<br>4.14<br>2.19<br>2.4 | 11.2 | 1.2 |
| **V** | 22<br>23<br>24<br>25<br>26 | 32.3<br>29.2<br>26.85<br>24.68<br>22.48 | 3.1<br>2.35<br>2.17<br>2.2<br>2.01 | 12.2 | 0.2 |
| **VI** | 27<br>28<br>29<br>30<br>31<br>32 | 20.47<br>18.33<br>16.22<br>14.82<br>13.23<br>11.03 | 2.14<br>2.11<br>1.4<br>1.59<br>2.2<br>1.46 | 11.3 | 1.1 |
| **VII** | 33 | 9.57 | 9.57 | 9.57 | 2.83 |
| **Total** | | | **79.25** | | **6.78** |

## RESULTS

The following results are obtained from the outcomes of table 7.

- Balance delay= $\frac{(7 \times 12.4) - 79.25}{7 \times 12.4} \times 100$

  = 8.69 %

- Line efficiency = 100 – 8.69

  = 91.31 %

- Smoothness index = $\sqrt{[(12.27-12.19)^2 + (12.27-11.29)^2+(12.27-12.27)^2+(12.27-12.2)^2+(12.27-11.3)^2+(12.27-9.57)^2]}$

  = 3.21

## CONCLUSIONS

The key inference obtained from the table is that the idle time is reduced drastically. It has been reduced from the existing time of 40 min to the proposed time of 6.78 min as derived by rank position method. This clearly defines that the productivity will increase thereby increasing the production rate of the industry. Also, standard time is obtained by careful considerations of the rating factor and allowances according to the effort and requirement of the worker in order to provide the complete utilization of the manufacturing plant.

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